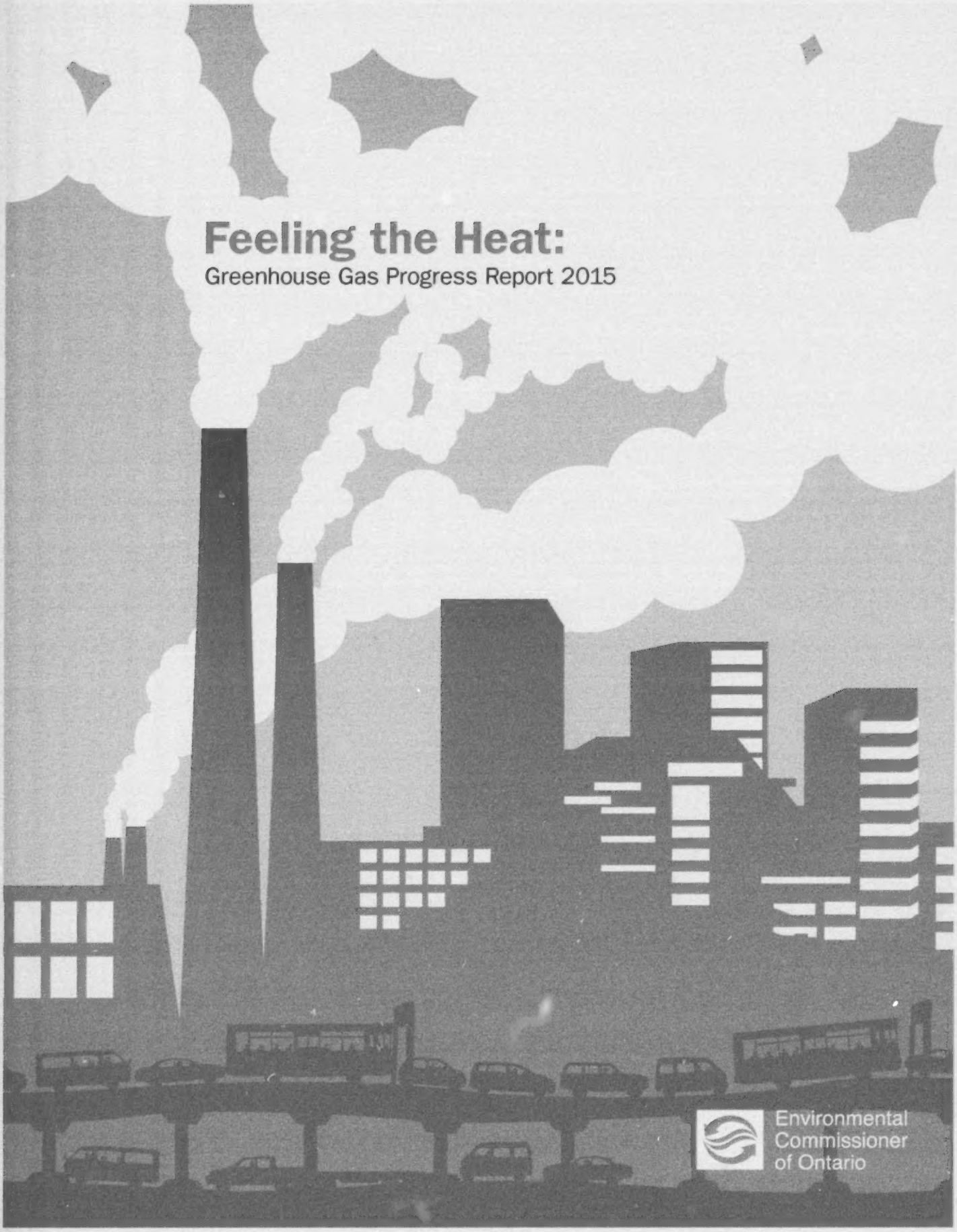
Feeling the Heat:

Greenhouse Gas Progress Report 2015



Environmental Commissioner of Ontario

July 2015

The Honourable Dave Levac
Speaker of the Legislative Assembly of Ontario

Room 180, Legislative Building
Legislative Assembly
Province of Ontario
Queen's Park

Dear Speaker:

In accordance with Section 58.2 of the *Environmental Bill of Rights, 1993*, I am pleased to present the Annual Greenhouse Gas Progress Report 2015 of the Environmental Commissioner of Ontario for your submission to the Legislative Assembly of Ontario. This Annual Report is my independent review of the Ontario government's progress in reducing greenhouse gas emissions for 2014-2015.

Sincerely,

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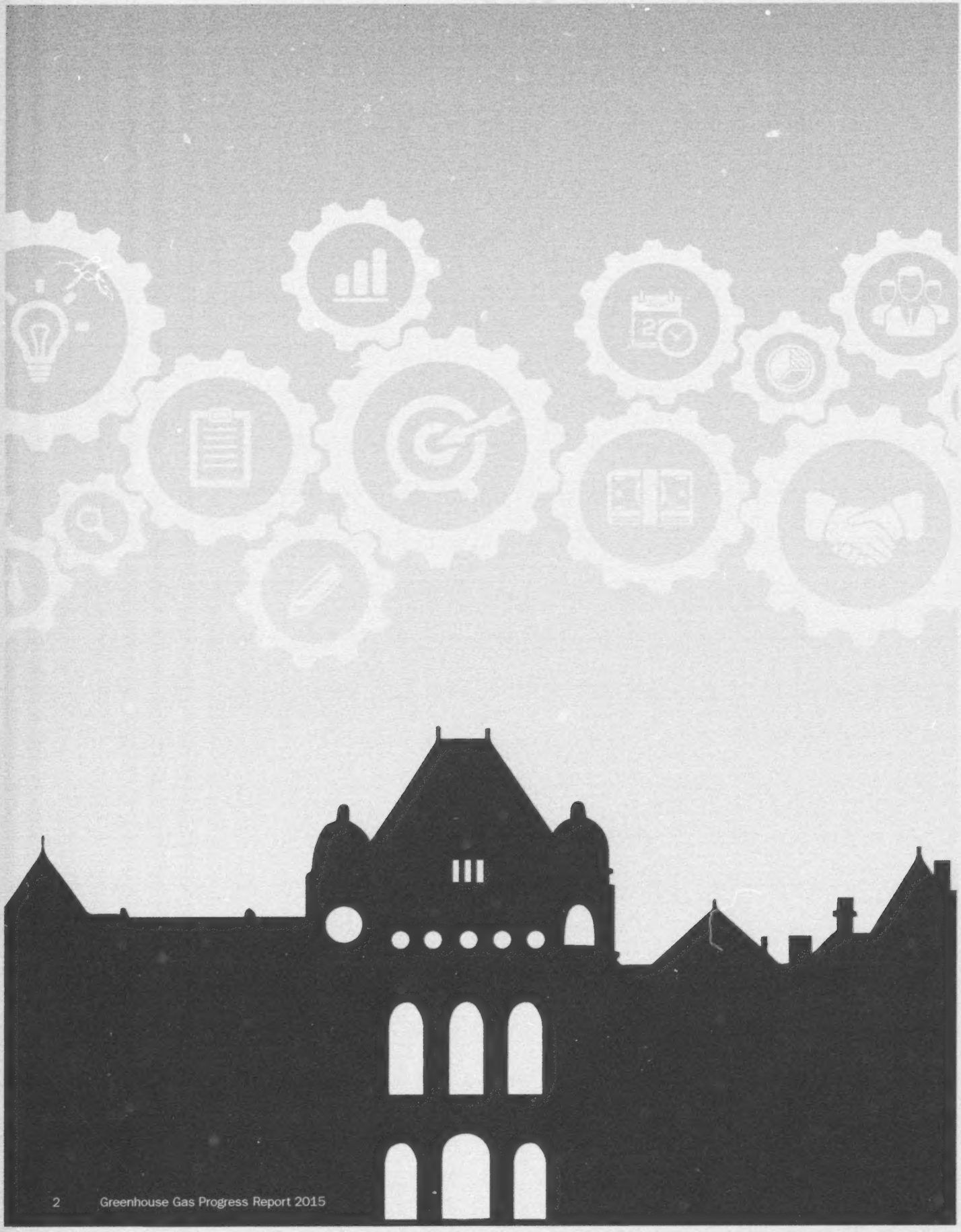


1. Introduction: Ontario's Changing Climate

1.1 Rebooting the Climate Change File

Ontario's climate is changing – both environmentally and in its policy mindset. In recent years, Ontario has struggled to make much progress on reducing greenhouse gas (GHG) emissions outside of the electricity sector. However, this seems poised to change as the government has recently unveiled several measures that suggest 2015 will be a key year for climate policy in Ontario.

Over the past year, Ontario has declared its commitment to major action on climate change. In June 2014, the government added "Climate Change" to the name of the Ministry of the Environment. In September 2014, the newly re-elected Premier issued a mandate letter to the Minister of the Environment and Climate Change that included clear instructions to update Ontario's climate change strategy, engage the public, and integrate climate change considerations into government decision-making processes.[1]

The government established a Climate Change Directorate in late 2014, housed within the Ministry of the Environment and Climate Change (MOECC), to co-ordinate, report on and drive climate action across all provincial ministries.[2] Ontario has also deepened its relationships with other provinces such as Alberta, British Columbia and especially Quebec, aiming to work together on climate and energy issues through bilateral action, as well as in other inter-provincial fora. In November 2014, Ontario signed a Memorandum of Understanding with Quebec on climate change that outlines key areas for future co-operation, including carbon pricing and regulatory alignment on emissions reporting. In March 2015 the government announced the appointment of a special advisor and an external advisory council on climate change. On April 13, 2015, the government announced that it will create a cap-and-trade system to achieve emissions reductions across sectors.[3]

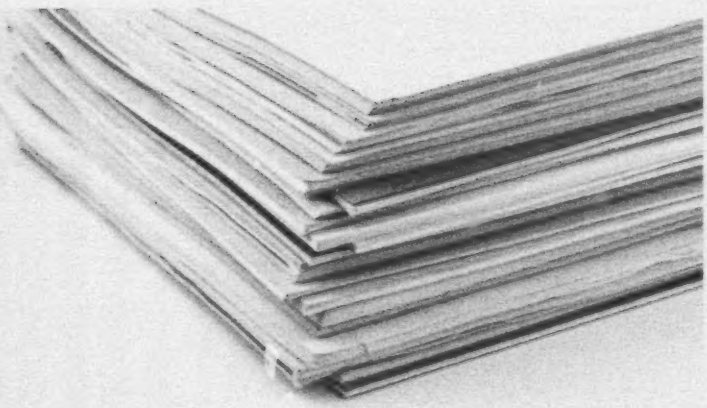
Drivers for Action

The push for Ontario's reboot on climate change has been growing steadily for years, with pressure coming from stakeholders, increasingly evolved climate science, more evidence of climate change impacts, and increasing international climate action. Municipalities, corporations and conservation authorities have been clamouring for greater provincial leadership, policy guidance and support (including financial support) to address climate change issues.

Over the past year, climate change has gained considerable attention at the highest political levels in the world's largest economies, providing further motivation for Ontario to act. The U.S. will be targeting emissions reductions in its highest emitting sector, electricity,[4] as well as methane emissions from oil and gas production.[5] The U.S. and China also announced a historic joint commitment to strengthen bilateral co-ordination on climate change.[6] Carbon pricing continues to spread across the globe; according to the World Bank, as of May 2014, there was some form of carbon price in over 40 countries and in 20 sub-national jurisdictions, covering 12 per cent of global GHG emissions.[7]

Despite little progress at past United Nations Framework Convention on Climate Change Conferences of the Parties, December 2015's session in Paris, France seems poised for a potential agreement. In anticipation, many jurisdictions are gearing up for Paris by introducing new climate change policies and plans – including Ontario.[8] Recently, Ontario and other sub-national governments have been playing a more prominent role in international climate diplomacy. The Compact of States and Regions, first announced at the September 2014 Climate Summit in New York City, with further signatories added at the Conference of the Parties in December 2014, looks to be a promising initiative to drive climate action at the state and regional government level.

An even bigger impetus for a reboot, however, is the growing recognition of the rapidly changing climate and the high costs of inaction. Thousands of scientific reports and peer-reviewed articles have established that the Earth's climate is changing. In Chapter 1 of the ECO's 2014 GHG Report, the ECO described the conclusions of Working Group I for the *Fifth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC); specifically, the IPCC concluded – with 95 per cent confidence – that human activities have been the dominant cause of climate warming since the 1950s. The IPCC findings, along with other reports, highlight how global average temperatures have increased and are expected to continue to rise, as well as the observed and expected intensification of extreme weather events such as heat waves and storms. It has become harder and harder to ignore the potential looming costs – economic, environmental and social – of climate change for Ontario.



In 2014 the IPCC released the remainder of its findings for the *Fifth Assessment Report*, culminating in a *Synthesis Report*. Among many other conclusions, that report calls for additional mitigation actions by all levels of government to decrease the likelihood of the many serious risks that the IPCC identifies from increased warming. The IPCC's *Synthesis Report* further highlights the need for adaptation measures to those climate change impacts that are unavoidable based on emissions already in the atmosphere (see **Appendix 1** for a more detailed summary of this report).

As the IPCC continues to publish increasingly stark, authoritative climate science reports, much of the world has moved beyond the old debates about whether and why climate change is happening. In keeping with this trend, the Ontario Legislature unanimously passed a motion on March 12, 2015, recognizing that climate change science and the serious threats it represents for Ontarians are now also beyond debate in Ontario politics.

The ECO has moved on as well; rather than expend pages in the introduction of our report making the case that climate change is occurring in Ontario, **Appendix 2** provides an overview of climate trends and projections for Ontario.

1.2 The Economic and Social Impacts of Climate Change

Climate change is not only altering our weather patterns and environment, it has also already begun to affect Ontario's economy and communities. Although the changing climate brings mixed positive and negative effects, it is predicted that the increasing economic costs related to damage to both public and private infrastructure and other property will be fiscally unsustainable for government.[9] Costs to the government associated with inaction also include potential negligence lawsuits, further discussed in the box on page 7. These costs of climate change impacts justify the upfront capital costs that are needed by the public and private sectors to adapt to the changing climate and more extreme weather events.[10]

At the same time, the long-standing belief that economic growth necessitates a certain degree of increasing GHG emissions has been debunked. As Ontario's *Climate Change Update 2014* indicates, economic growth in Ontario can break from this historic trend of emissions growth.[11] A low-carbon economy presents important economic opportunities for the province.

Economic Impacts to Industry

Many sectors of the Ontario economy will be challenged by a changing climate. Resource-based industries will be especially hard-hit. Although a warmer climate potentially brings a longer growing season, a 2014 Natural Resources Canada (NRCAN) study explains that Ontario agriculture could be at greater risk from drought, pests, disease and climate variability.[12] The costs to the province could be enormous; between 2000 and 2004 alone, droughts in Ontario resulted in crop insurance payouts of $600 million, and according to the National Round Table on the Environment and the Economy (NRTEE) in 2010, this figure will only rise.[13]

Climate change has already had variable effects on Ontario's tourism industry. For example, NRCAN's 2014 study highlights how recent warm winters have had negative impacts on the ski industry, while warm weather activities, such as golf, may benefit from an extended summer season.[14] This same report discusses how many other sectors of the economy will be affected by climate change; for example, the manufacturing sector may be negatively affected as a result of extreme weather damaging infrastructure and interrupting supply chains, as well as higher temperatures and humidity affecting employee health and productivity.[15]

Even where increases in annual average precipitation are projected, increased evaporation and evapotranspiration due to higher temperatures may lead to overall lower water levels.[16] Lower water levels could negatively affect important transportation networks, such as the Great Lakes-St. Lawrence Seaway. Shallower navigation channels, docks and harbours reduce the amount of cargo that ships can carry and may require more trips; as a result, shipping costs could increase.[17] According to the NRTEE, lower water levels in lakes and rivers will also reduce the potential for hydro-electric generation in parts of Ontario and could lead to economic losses of $660 million per year, as well as result in energy shortages during peak summer demand.[18]

In the Far North of Ontario, the winter road network is a vital link for communities and resource industries that are not serviced by a permanent road system. Shortened, warmer winters mean a reduced season for building and operating winter roads.[19]

Risks to Public Assets and Government Operations

Ontarians face costly climate change-related risks to public assets and government operations, including infrastructure (e.g., roads, the electricity grid and buildings), services (e.g., emergency response), and finances (e.g., consequences of reduced insurance affordability). Additional investment over a number of years will be required to make public infrastructure more resilient to extreme weather. Delivery of government services will be affected in different ways: some impacts may be sudden due to extreme weather and others more gradual due to longer-term climatic shifts. For example, in 2012, Emergency Management Ontario projected that emergency management services will be challenged to keep up with the increased frequency and greater severity of natural disasters, such as floods, predicted under a changing climate.[20]

The provincial government has already begun to encounter the need to make additional financial payouts due to extreme weather (ultimately coming out of taxpayers' pockets). Periodic provision of emergency funding to hard-hit municipalities or individuals may be needed, as was required during the Burlington flood in 2014 and the December 2013 ice storm in the Greater Toronto Area. As the number and magnitude of natural disasters increase, Ontario's disaster fund, the Ontario Disaster Relief Assistance Program[4], will be under additional stress to provide financial support to hard-hit communities and individuals. Furthermore, under its proposed expansion of crop insurance for Ontario farmers, the government will likely need to make additional payouts for crop failure due to extreme weather. Existing government insurance or emergency management programs such as Ontario's disaster fund were not designed with climate change in mind, highlighting the need for a more strategic approach to funding adaptation.

[4]Changes to Ontario Disaster Relief Assistance Program (ODRAP) are likely coming: in the 2014 mandate letter to the Minister of Municipal Affairs and Housing, the Premier instructed the Minister to examine ODRAP to ensure its design and eligibility criteria reflect current needs in addressing extreme weather events. The future of this program is more important than ever given that, as of February 1, 2015, the federal government reduced financial support for the provinces from the Disaster Financial Assistance Arrangements program, meaning Ontario will have to cover an increased share of disaster-related rebuilding costs.

Provincial Legal Liability for Damage Caused by Climate Change

Extreme weather events have already begun to stress infrastructure in Ontario, and will continue to do so, even in the best-case GHG mitigation scenario.[21] The resulting damage to personal property and/or human health may create legal liabilities for the provincial government, most likely in the form of negligence lawsuits.[22] Such lawsuits, if successful, could result in costly awards or settlements.

Some legal research states that the provincial government could be held legally liable for negligence in relation to an extreme weather event in circumstances where the following basic elements are present:

- an individual or group has suffered personal or property damage;
- the damage was, at least in part, caused by the provincial government's acts or omissions;
- the provincial government had a legal duty to the individual/group; and
- the provincial government ought to have reasonably known its act or omission could cause a risk for that individual/group (and knowledge of extreme weather events might factor into this reasonableness analysis).[23]

The provincial government is responsible for managing or regulating various types of infrastructure. Depending on how the province executes such responsibilities, these obligations could create liability for the government as a potential defendant in a negligence lawsuit. For example, the province could face liability arising from its role in establishing design standards[24] and in providing regulatory approval authority for stormwater systems.[25] Extreme weather events increase the likelihood of flooding and sewer back-ups, which can cause significant property damage (see the ECO's 2013 GHG Report.)

Another example is publicly-owned electricity transmission infrastructure. The courts have found that Ontario's crown corporation Hydro One has a duty to deliver electricity safely and that the former Ontario Hydro had a duty to have adequate emergency response systems in place.[28] Similarly, the provincial government has been found to have a responsibility to protect against hazards from electrical infrastructure on provincially owned land that may cause physical harm to members of the public.[27] As extreme weather events increase, the province will face greater potential liability, both via its ownership of electricity transmission assets and as an owner of land where electrical infrastructure is installed, from weather-related electrical hazards.[29]

The province also has a duty to plan, design, maintain and repair provincial roads and highways[30] and to ensure they are safe for use.[31] The province's potential liability with respect to this responsibility could increase as a result of the predicted rise in intense rain events, freeze-thaw cycles, and climate variability.[32] What's more, the government's own precipitation projections suggest the province should be aware of these climate change risks, factoring into the reasonableness analysis of the province's actions (or inactions) under the law.[33]

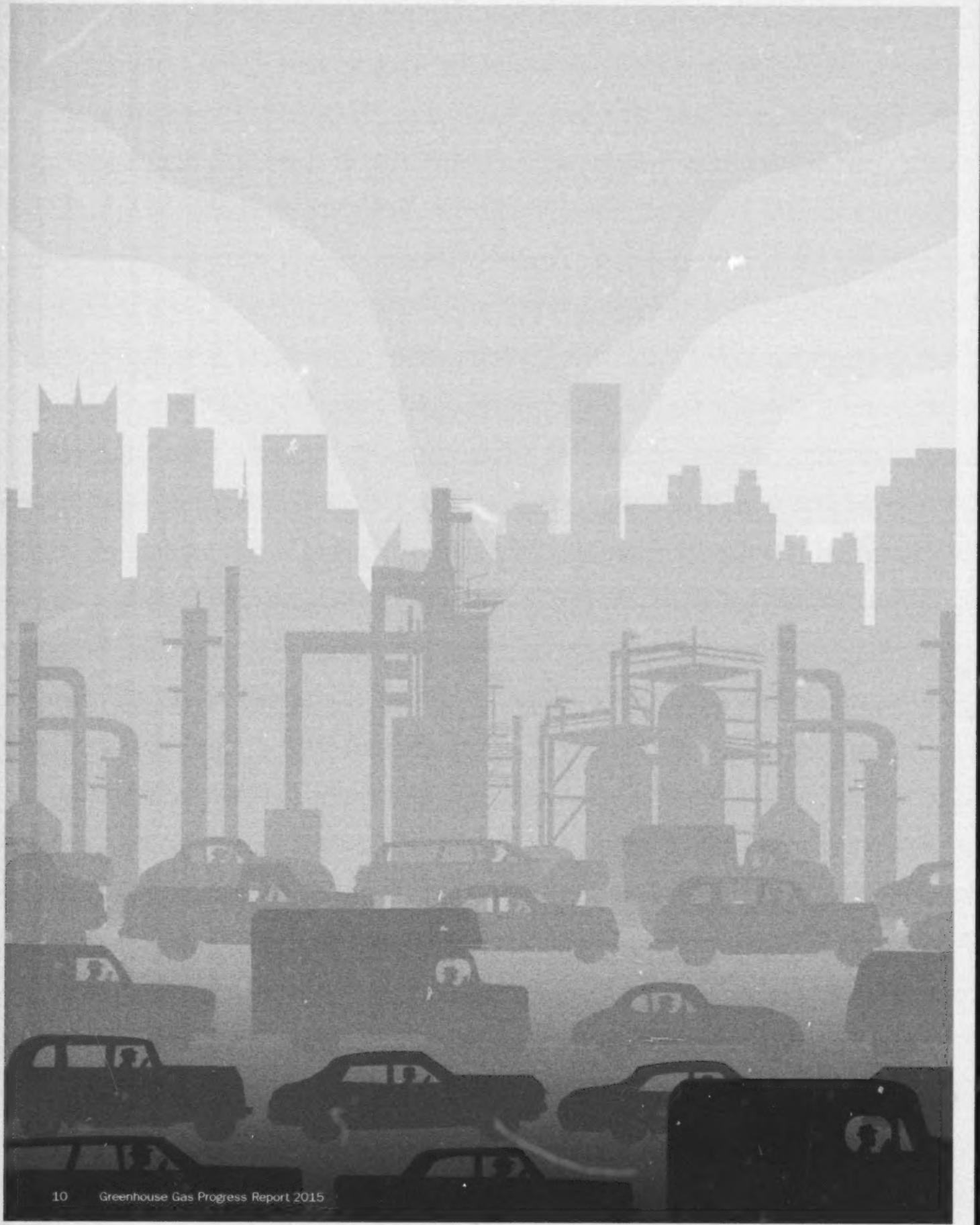
In negligence cases, the court will consider various factors when determining liability, including whether the action or inaction that lead to the damage was reasonable.[34] The assessment of "reasonableness" could take into account relevant statutory requirements and guidance, publicly available knowledge, as well as government custom and practice.[34] Government policy decisions are generally immune from liability; however, legal experts have pointed out that governments that fail to consider climate change in policy making will not be immune from potential negligence claims if this information would have been considered by a reasonable person (or government) in similar circumstances.[35]

Climate Change and Human Health

Climate change also holds serious consequences for the health of Ontarians. NRCAN reported in 2008 that by 2050, cities such as Toronto and Windsor can expect double the current average number of days exceeding 30°C.[36] As a result, the report continues, mortality due to heat could also double by the 2050s, while mortality from air pollution could rise as well.[37]

The warming climate is also heightening the risk of certain diseases. As the ECO wrote in our 2009/2010 Annual Report, and NRCAN discussed in a 2014 report, black-legged ticks – the species that transmits Lyme disease – are spreading northward into Canada at a rate of 35–55 km/year, exposing more of Ontario to this debilitating disease.[38] Annual incidences of Lyme disease in Canada have already increased from approximately 144 cases in 2009 to 682 cases in 2013.[39] In 2010 the NRTEE reported that warmer winters and warm, humid summers may also result in the spread of mosquitoes that carry West Nile Virus.[40]

Extreme weather can bring about other health risks. According to the Report of the Walkerton Inquiry, one of the many factors that contributed to the deadly outbreak of *E. coli* in Walkerton in 2000 was the heavy rain that assisted the transport of manure into the drinking water supply.[41] The 2008 NRCAN scientific literature review on the impacts of climate change on Ontario also reported that intense rainfall and ice storms can result in traffic accidents, while flooded homes can lead to the spread of toxic molds and poor indoor air quality.[42]



2. Ontario's Latest GHG Numbers

The Environmental Commissioner of Ontario reports annually to the Legislative Assembly of Ontario on the progress of the Ontario government towards reducing the province's GHG emissions, as required by the *Environmental Bill of Rights, 1993*. This section uses the most recent Environment Canada data to assess the province's progress towards meeting its GHG emissions reduction targets, established in 2007.[43] The three provincial targets are to reduce Ontario's annual GHG emissions by:

- 6 per cent below 1990 levels by 2014 (to approximately 171 Megatonnes [Mt] CO_2 equivalent);
- 15 per cent below 1990 levels by 2020 (to approximately 155 Mt); and
- 80 per cent below 1990 levels by 2050 (to approximately 36 Mt).

Ontario recently announced a 2030 mid-term target of 37 per cent below 1990 levels (equivalent to 115 Mt).

2.1 Overall Emissions in 2013

According to the 2015 National Inventory Report (NIR), Ontario's GHG emissions in 2013 were 171 Mt, equivalent to emissions in 2012 (and 2009).[44] This figure is the lowest annual level of emissions since the baseline year of 1990 (and 1991), when emissions were 182 Mt. (Note: this baseline number is higher than previously reported based on the use of newer methods of calculating GHG emissions; see box.)

Revised Framework for Calculating GHG Emissions

In this year's edition of the National Inventory Report, it became mandatory for Environment Canada to use the revised United Nations Framework Convention on Climate Change emissions reporting guidelines. This resulted in recalculations of previous years' emissions, and the 1990 baseline year is now higher than was reported in previous years (e.g., the baseline was reported to be 177 Mt in 2014, but was increased to 182 Mt in 2015).* The recalculation is mainly due to an updated value for the global warming potential of two greenhouse gases, methane and nitrous oxide, resulting in higher carbon emissions across all years. The sectors most affected by this change are residential buildings, agriculture, and waste.

* Each year Canada produces a National Inventory Report, which provides the most recent, as well as historic, GHG data for Canada and each province. Due to continual improvements to the way emissions estimates are modelled and calculated, historic data is often restated. Accordingly, historic numbers for some years, including the baseline year of 1990, may not exactly align with data on which the ECO has previously reported and commented.

With Ontario's emissions projected to be lower in 2014 due to the closure of its final coal-powered electricity plant, Ontario looks likely to meet its 2014 target (which is also 171 Mt). As shown in **Figure 1**, the last several years have witnessed a significant decline from the peaks experienced roughly between 2000 and 2005, when emissions from coal-fired electricity generation were highest.

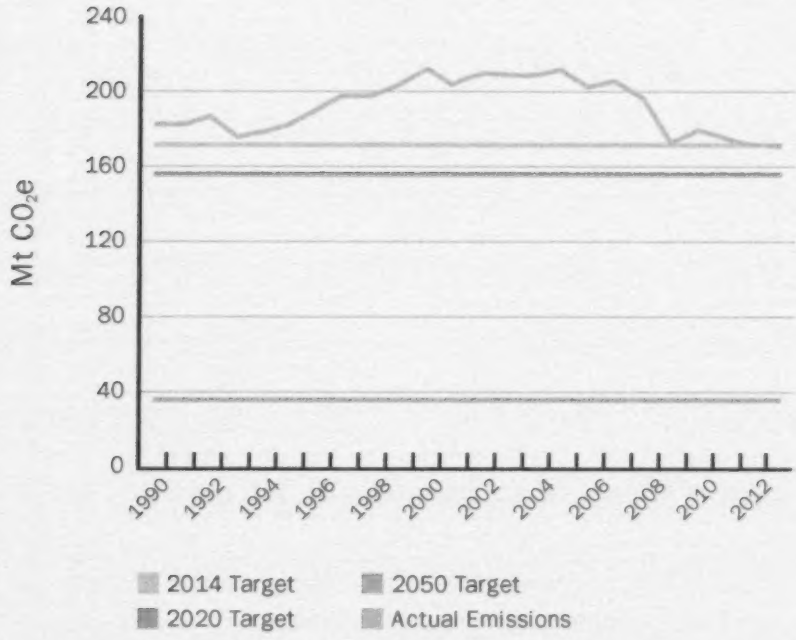


Figure 1. Ontario greenhouse gas emission trends and targets (1990-2013). (Sources: Environment Canada. National Inventory Report – Greenhouse Gas Sources and Sinks in Canada 1990-2013 (2015); Go Green: Ontario's Action Plan on Climate Change (2007); Ontario's Climate Change Update 2014 (2014)).

However, meeting the 2020 target will prove more difficult. Ontario faces a large gap (19 Mt – equal to 11 per cent of its total current GHG emissions[a]) between the province's projected 2020 emissions based on current policies and trends and the 2020 target. Without new policy initiatives, the majority of Ontario's emissions reductions (78 per cent in 2020) will have come from the single initiative of phasing out the use of coal in the electricity sector. The government's biggest climate change challenge going forward is to achieve sufficient GHG reductions beyond the electricity sector to meet its 2020 target.

[a] This 19 Mt gap was as of September 2014 and is based on the previous year's National Inventory Report.

2.2 Sector-Specific Emissions

Figure 2 shows Ontario's GHG emissions from each sector and how they have changed from 1990 to 2013. The electricity sector alone has seen a 58 per cent reduction in emissions over this time period, with the industrial sector contributing a further 26 per cent reduction, mostly due to reduced industrial production in the province.[46] The closure of the coal plants will not be fully reflected in Ontario's emissions profile until the 2015 emissions data becomes available.

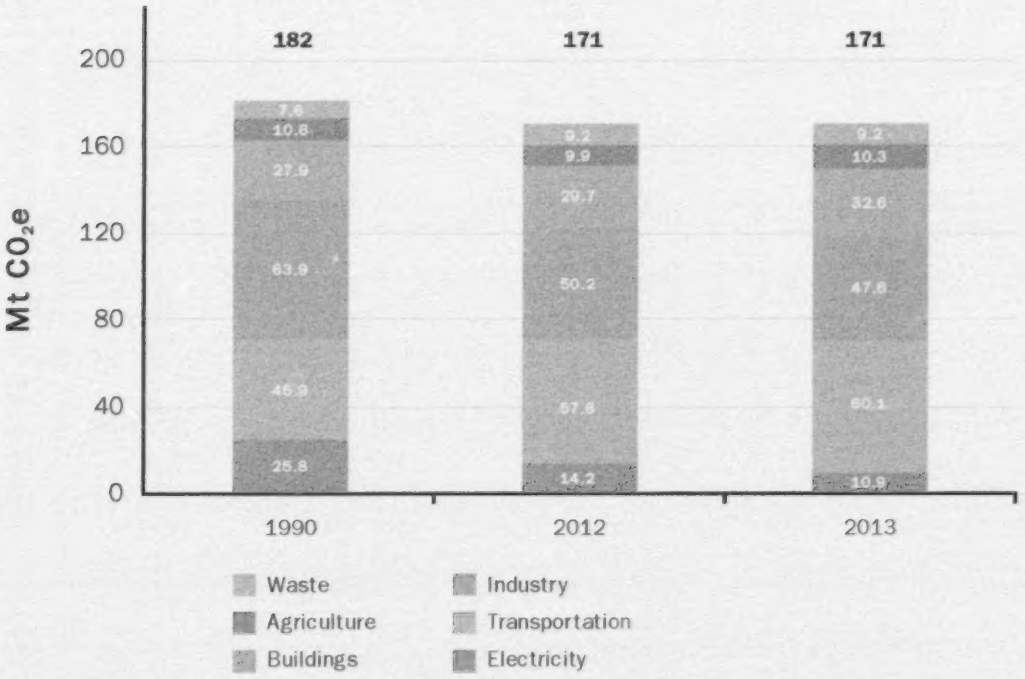


Figure 2. Ontario greenhouse gas emissions by sector for 1990, 2012 and 2013. (Source: Environment Canada. National Inventory Report – Greenhouse Gas Sources and Sinks in Canada 1990-2013 (2015)).

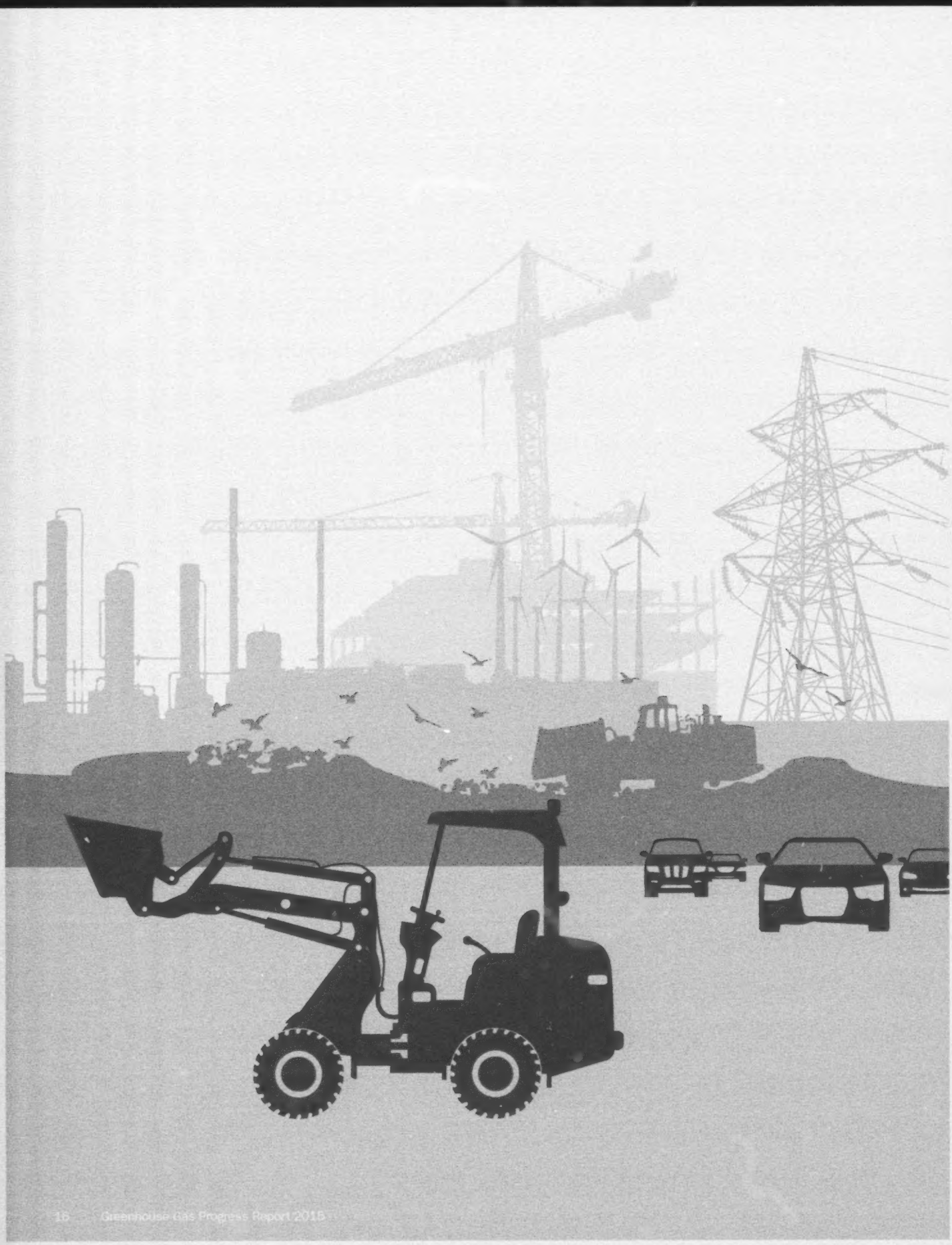
Since 1990, emissions reductions in the electricity and industry sectors have been partially offset by the 31 per cent increase in emissions from the transportation sector. Emissions in the buildings and waste sectors have also risen (17 per cent and 20 per cent, respectively). The transportation sector remains the largest contributor to the overall provincial inventory, with emissions rising 4 per cent from 2012 to 2013. Although emissions intensities have fallen in many sectors, in some sectors these gains are at least partially offset by economic and population growth.[47]

A more detailed breakdown of sector emissions is provided in **Table 1**.

Table 1. Ontario's Greenhouse Gas Emissions 1990–2013 (Source: Environment Canada. National Inventory Report – Greenhouse Gas Sources and Sinks in Canada 1990-2013 (2015)).

Sources	Emissions ($Mt CO_2e$)		Change from 1990–2013		Percentage each sector contributes to 2013 total
	1990	2013	$Mt CO_2e$	%Δ	%
Electricity	25.8	10.9	-14.9	-58	6
Transportation	45.9	60.1	+14.2	+31	35
Road (passenger)	27.3	32.7	+5.4	+19.8	
Road (freight)	8	13.4	+5.4	+67.5	
Off-road (gasoline and diesel)	5.6	9.2	+3.6	+64.3	
Domestic Aviation	2.2	2.3	+0.1	+4.5	
Domestic Marine	1.0	1.2	+0.2	+20	
Rail	1.8	1.3	-0.5	-27.8	
Industry	63.9	47.6	-16.3	-25.5	28
Fossil fuel refining	6.1	6.1	0	0	
Manufacturing	22	16.1	-5.9	-26.8	
Mineral Production (cement, lime, mineral products)	4.1	3.6	-0.5	-12.2	
Chemical Industry	10	0	-10	-100	
Metal Production (iron and steel)	10.9	7.7	-3.2	-29.4	
Fugitive Sources	1.6	1.3	-0.3	-18.8	
Other[a]	9.3	12.8	+3.5	+37.6	
Buildings	27.9	32.6	+4.7	+17	19
Commercial and Institutional	9.1	11.9	+2.8	+30.8	
Residential	18.8	20.7	+1.9	+10.1	
Agriculture	10.6	10.3	-0.3	-3	4
Enteric Fermentation	4.4	3.6	-0.8	-18.2	
Manure Management	2.1	1.9	-0.2	-9.5	
Agricultural Soils	3.9	4.6	+0.7	+17.9	
Waste	7.6	9	+1.4	+19	5
Solid Waste Disposal on Land	7.1	8.4	+1.3	+18.3	
Wastewater Handling	.2	.3	+0.1	+50	
Waste Incineration	.3	.3	0	0	
TOTAL	182	171	-11	-6	100

[a]The "other" category includes emissions from stationary combustion in mining, construction, agriculture and forestry; emissions from pipelines; emissions associated with the production and consumption of halocarbons; and emissions from the use of petroleum fuels as feedstock for petrochemical products. Subsector figures do not exactly match sector totals due to rounding errors and the fact that this table does not list all minor subsectors. The ECO adds up the emissions subcategories to calculate the sector totals so they may not exactly match the rounded numbers presented in the NIR.



3. Review of Ontario's Progress on GHG Reductions

The Environmental Commissioner of Ontario annually reviews all government reports on climate change and GHG reductions published during the previous year, as required by the *Environmental Bill of Rights, 1993*. This section reviews the Ontario government's most recent GHG annual report, Ontario's *Climate Change Update 2014*, which provides an update of Ontario's GHG emissions and progress towards meetings its GHG reduction targets as set out in the government's 2007 *Climate Change Action Plan*.[48] This section also reviews additional climate change-related policy developments that occurred between July 9, 2014 (the release date of the ECO's last GHG report) and April 15, 2015.

The Ontario government's *Climate Change Update 2014*, released by the MOECC in September 2014, provides a detailed analysis of Environment Canada's 2014 National Inventory Report emission numbers for Ontario (supplemented by the MOECC's data and projections). The 2014 update report explains the sources of emissions in the province and why they may be rising or falling, including the impact of policies on GHG emissions. The report also discusses expected future emissions trends in the province based on current government policies, and mentions some potential new policy directions for each sector.

The following sections outline both existing government policies and progress towards developing new policies and regulations to reduce GHG emissions across the transportation, building, industry, agriculture, electricity, and waste sectors. The discussion focuses on progress and barriers towards meeting a rapidly approaching deadline: Ontario's 2020 GHG emissions reduction target. The sectoral reviews are presented from highest to lowest emitting sector.

3.1 Cross-Sectoral Developments

In the ECO's 2014/2015 reporting year, the government announced a number of measures that demonstrate a renewed commitment to climate action, such as adding "Climate Change" to the name of the Ministry of the Environment and including a strong emphasis on climate change in the Premier's mandate letter to the Minister of the Environment and Climate Change (see Section 1.1 of this report for more detail).

In addition, on February 12, 2015, the government posted a climate change discussion paper on the Environmental Registry for a 45-day public comment period (Environmental Registry #012-3452). The paper supported a comprehensive stakeholder engagement process that the province carried out in early 2015 to underpin the development of its new climate change plan. The paper outlined the key areas in which the government intends to introduce new policies to: take action in each sector, including putting a price on carbon; support science, research and technology; and promote climate resilience and risk management.

In April 2015, the government announced that it will introduce a cap-and-trade system. As stated in previous GHG reports, the ECO is supportive of carbon pricing in general as an economically efficient approach to reducing emissions.[49] Although globally cap-and-trade systems targeting GHG emissions are still in the initial stages of implementation, research has shown that they have been able to incent emissions reductions.[50]

The province has committed to completing its updated climate change strategy (covering both climate mitigation and adaptation) by the end of 2015.[51] With that, the ECO expects 2015 to bring numerous climate policy announcements.

No Breakdown of GHG Emissions Projections

The ECO assesses the province's progress in reducing emissions in each of the key sectors: transportation, industry, buildings, electricity, agriculture and waste. However, the ECO's role in assessing the province's progress in reducing GHG emissions on an initiative-by-initiative basis for each sector is hindered by the MOECC's "lumping" approach to reporting.

The MOECC has long used a lumping approach in its climate change progress reports when reporting projected emissions reductions for each sector; the ministry reports the expected emissions reductions for each sector as an aggregate of all GHG-reduction initiatives listed for that sector. For example, within the transportation sector, Ontario's *Climate Change Update 2014* lists six separate initiatives (though one of these is a federal initiative), but lists their projected GHG reductions in one lump figure. Although this approach is likely used due to the difficulty of attributing emissions reductions to any single initiative, it makes it challenging to ascertain whether fluctuations in the projections for a sector over time are due to the success or failure of any specific policy, or due to revised modelling assumptions.

The ECO highlighted this problem in our 2011 GHG Progress Report, but the MOECC has not changed its approach.

3.2 Transportation

At 60.1 Mt (35 per cent of total emissions), the transportation sector – including road, rail, domestic air and marine modes – remains Ontario's largest source of GHG emissions, and consequently, the biggest hurdle to achieving its 2020 GHG reduction target. What's more, GHG emissions from this sector have grown significantly, from 45.9 Mt in 1990, to 57.8 Mt in 2012, to 60.1 Mt in 2013. That is a 31 per cent increase in transportation emissions since 1990.

The ministry's emissions projections for transportation have fluctuated significantly over time. In 2007, the province projected that emissions cuts from transportation would contribute 19 Mt of GHG emissions reductions in 2020.[52] In the MOECC's *Climate Change Progress Report 2012*, the province dramatically scaled back its projected reductions for this sector in 2020 to only 3.9 Mt.[53]

Most recently, the MOECC's *Climate Change Update 2014* projected a slightly more ambitious reduction for the sector for the year 2020 – an improvement from 3.9 to 4.6 Mt.[54] The only new transportation initiative listed in Ontario's *Climate Change Update 2014* compared to its *Climate Change Progress Report 2012* is the Greener Diesel regulation (O. Reg. 97/14) made under the *Environmental Protection Act*; nonetheless, it is not possible to attribute the additional projected reduction of 0.7 Mt to this specific transportation initiative with certainty because of the ministry's aggregated reporting. The new projection could be the result of revised modelling of GHG reductions from other listed transportation initiatives, such as the province's Big Move regional transportation plan.

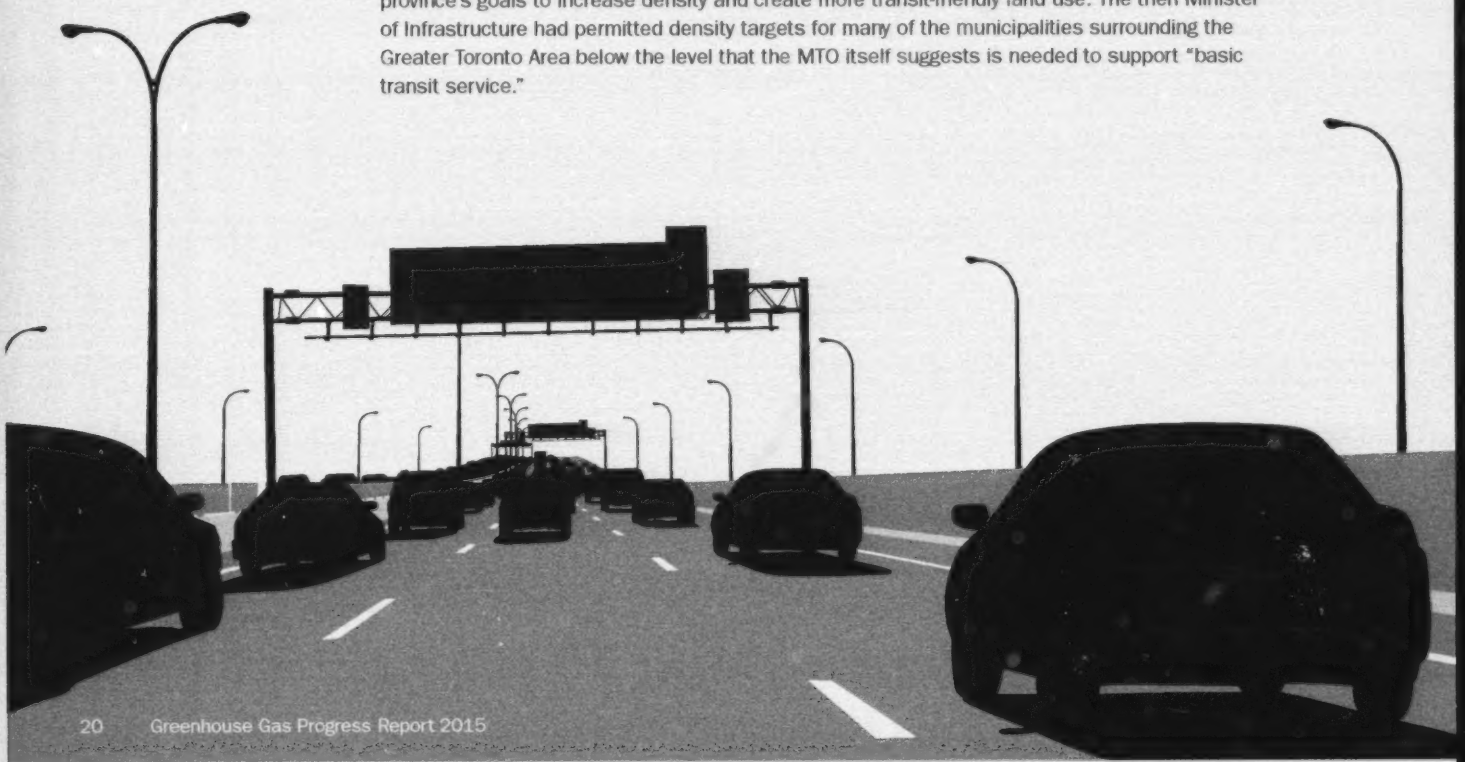
Since Ontario's *Climate Change Update 2014* was released in September, the Ministry of Transportation (MTO) continues to work on implementing pre-existing transit, electric vehicle, and cycling policies (though the latter two have represented GHG reductions too insignificant to be listed in Ontario's *Climate Change Update 2014*). The Premier's 2014 mandate letter to the MTO also called on the ministry to prioritize the implementation of high-occupancy toll (HOT) lanes; however the MTO has stated that it does not currently have sufficient data to calculate, model, or predict the impacts of HOT lane projects.[55] Beyond these measures, no new transportation initiatives have been implemented or proposed that would result in significant GHG reductions.

Another challenge in the transportation sector is the uncertainty that fluctuations in gasoline prices present for future GHG emissions. In the province's *Climate Change Progress Report 2012*, emissions projections for the sector were lowered partly based on higher prices for gasoline.[56] However, contrary to this forecast, gas prices dropped in 2014. A sustained period of lower gas prices could encourage drivers to drive more and purchase higher gas-consuming vehicles (such as pickup trucks and sport-utility vehicles) and actually increase the sector's GHG emissions, highlighting how unpredictable market forces can be within the sector.

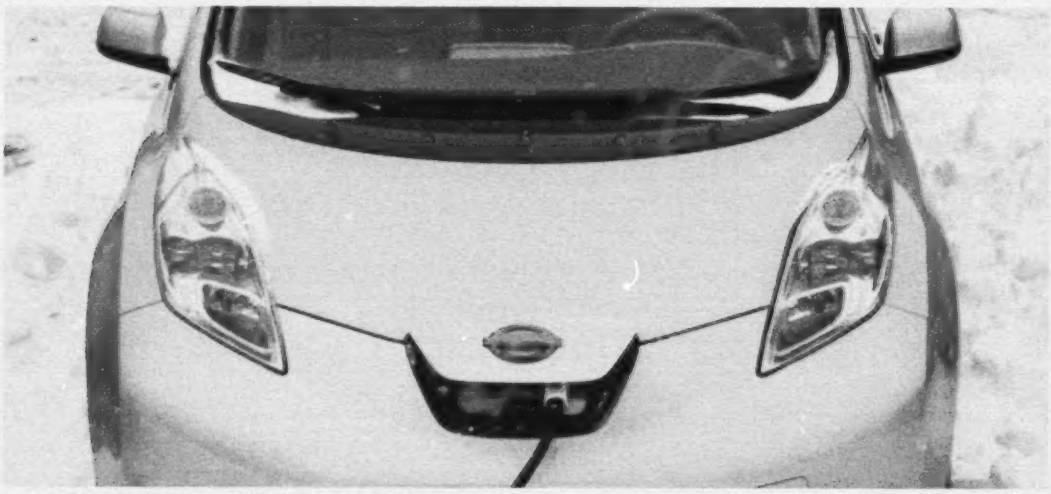
Transit

The MTO continues to fund and expand public transit throughout the province, which if done well could help get people out of their cars – the largest source of transport emissions.[57] For example, in 2014, 96 municipalities received a total of $325.1 million in funding for improved public transit via the province's gas tax; a source of funding that was made permanent in 2013.[58] The ministry is also continuing to work on important transit expansion projects, including the Eglinton Crosstown Light Rail Transit line and the Union-Pearson Express in Toronto, as well as transforming existing GO commuter rail into an electrified rapid transit system for the Greater Toronto and Hamilton Area.

Ontario's *Climate Change Update 2014* also points to the *Provincial Policy Statement, 2014* and Ontario's *Growth Plan for the Greater Golden Horseshoe, 2006* as supporting policies that promote mixed land uses and higher densities. This in turn should encourage greater use of transit, as well as reduce vehicle kilometres travelled through other means (i.e., fewer and shorter car trips; more walking, cycling and car-pooling). However, when the ECO examined the implementation of the Growth Plan in our 2013/2014 ECO Annual Report, we found that it was not achieving the province's goals to increase density and create more transit-friendly land use. The then Minister of Infrastructure had permitted density targets for many of the municipalities surrounding the Greater Toronto Area below the level that the MTO itself suggests is needed to support "basic transit service."

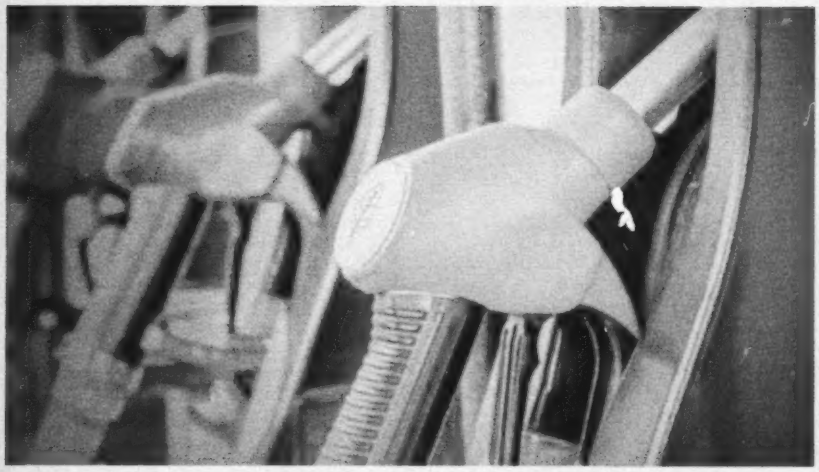


The government is currently reviewing the *Growth Plan for the Greater Golden Horseshoe, 2006*. In addition, on March 5, 2015, the government proposed Bill 73, the *Smart Growth for Our Communities Act, 2015*, which proposes to (among other things) amend the *Development Charges Act, 1997* to enable increased revenue for municipal transit. The Premier's 2014 mandate letter to the Minister of Municipal Affairs and Housing had directed the Minister to amend the *Development Charges Act, 1997* to support "the development of sustainable, transit-friendly complete communities" through improved land use planning and smarter growth.



Electric Vehicles

Ontario's low-carbon electricity mix means that electric vehicles have the potential to greatly reduce emissions in the transportation sector. In 2009, the MTO established an ambitious goal to have 1 in 20 vehicles driven in Ontario by 2020 be an electric vehicle (EV).[59] The MTO has been subsidizing electric vehicle sales and charging stations in the province through its "Electric Vehicle Incentive" and "Electric Vehicle Charging Incentive" programs, but progress towards this EV target has been very modest. As of February 2015, there are only 4,030 electric vehicles in the province – to put this number in perspective, it represents approximately 1 in 1,900 passenger vehicles in Ontario in 2014.[60] As it stands, the MOECC has not determined the EV initiative to warrant being listed in Ontario's *Climate Change Update 2014*, presumably because the GHG reductions are too small.



Low Carbon Fuel

In 2007, the government committed to establishing a Low Carbon Fuel Standard (LCFS) for vehicles. The LCFS commitment was expected to reduce the carbon intensity of transportation fuels by 10 per cent by 2020. However, the Ministry of Energy has made little measurable progress toward establishing an LCFS in Ontario in the almost eight years since the commitment was made.[62] In light of stalled progress, in our 2012 Energy Conservation Progress Report the ECO called on the province to act on this commitment and recommended that responsibility for implementing an LCFS in Ontario be reassigned to the Ministry of the Environment (now the MOECC).[63]

The MOECC has proven it is better positioned to take charge of an LCFS for two reasons: the ministry already has responsibility for regulating other transportation fuel qualities to control emissions; and, the MOECC has demonstrated through design elements of the Greener Diesel Regulation (primarily using lifecycle analysis to model GHG emissions[64]) that some of the issues the Ministry of Energy deemed insurmountable to establishing an LCFS can in fact be resolved, at least partially.[65] The ECO reiterates our previous recommendation that responsibility for implementing a low-carbon fuel standard be assigned to the MOECC.[66]

3.3 Industry

The industrial sector accounts for the second highest share of GHG emissions in Ontario at 28 per cent or 47.6 Mt. This sector reduced its GHG emissions by 21 per cent between 1990 and 2012, but recently emissions have been increasing and the MOECC projects GHG emissions will continue to increase. GHG reductions in this sector are attributable primarily to reduced industrial production (including plant closures) in recent years, as well as some improvements in energy efficiency. For example, the MOECC reports that the average emissions intensity of manufacturing decreased by 34 per cent between 1990 and 2012.[67]

The industrial sector has historically been subject to relatively weak policies and oversight aimed at reining in its GHG emissions; the sole GHG policy initiative aimed at the industrial sector that is mentioned in Ontario's *Climate Change Update 2014* is the natural gas demand side management program (discussed below, in the Buildings section). However, the sector will soon be targeted for greater emissions reductions, as a result of two policy developments.

In April 2015, Ontario announced that it will introduce a cap-and-trade system under the Western Climate Initiative (WCI), of which it has been a member since 2008. Ontario intends to join Quebec and California, the other two jurisdictions in North America that have implemented cap-and-trade systems through WCI. WCI creates a common design and administrative framework for emissions trading, thus enabling the future linking of systems across jurisdictional boundaries.[68] While the exact design details of Ontario's system had not been made public at the time of publication, WCI design documents, Quebec and California's systems, as well as Ontario's past carbon pricing discussion papers[69] provide general information about the likely design decisions Ontario will make. The system will likely initially cover large industrial emitters (facilities that emit more than 25,000 tonnes of GHGs in a year). These large emitters have already been reporting their emissions to the MOECC since 2010.[70] Emissions in other sectors of the economy can be targeted indirectly by targeting upstream fuel distributors or directly by allowing offsets (as Quebec[71] and California[72] have done).

Second, on April 13, 2015, the MOECC released a new regulation that aims to reduce coal and petroleum coke use in energy-intensive industries such as cement, lime, iron and steel.[v] In 2012, 29 per cent of the cement industry's energy use came from coal; whereas in the iron and steel sector, 4.3 percent of energy use was from coal and 49 percent was from coke.[73] The regulation encourages facilities to switch to fuels that have lower carbon emissions intensity than coal or petroleum coke (e.g., various forms of biomass and other organic matter). Given the uncertainties regarding how many plants will choose to participate and the exact nature of the replacement fuel, the GHG benefits of the regulation are difficult to predict. The ECO will review this regulation in a future report.

[v] O. Reg. 79/15: Alternative Low Carbon Fuels, made under *Environmental Protection Act*, *R.S.O. 1990*, c. E.19.

3.4 Buildings

The buildings sector in Ontario continues to be the third largest source of GHG emissions. In 2013, it represented 32.6 Mt, or 19 per cent, of Ontario's GHG emissions. Building emissions have risen fairly steadily since 1990, increasing by 17 per cent between 1990 to 2013, tied to economic and population growth; amid the general upward trend are some annual fluctuations in emissions due to changes in weather patterns (determining heating and cooling demand) and commercial activity.[74] The MOECC projects that this sector's rising emissions trend will continue.

While the electricity sector continues to decarbonize, the reliance of the buildings sector on natural gas for space and water heating presents a key challenge to the Ontario government as it attempts to meet its 2020 emissions reduction target. Between 1990 and 2012, demand for natural gas in the building sector has increased in both the residential (23 per cent increase) and commercial/institutional (30 per cent increase) building sectors, mostly due to large increases in floor space.[75]

Policies that the government has implemented in recent years to drive emissions reductions in this sector include changes to the Ontario Building Code (the latest update – the 2012 code – came into effect on January 1, 2014 and is renewed in five-year year cycles),[76] natural gas demand side management programs, energy efficiency regulations and standards, and changes to the *Provincial Policy Statement, 2014* that promote more compact building types.[77] Ontario's *Climate Change Update 2014* predicts that these initiatives will achieve 2-3 Mt of emissions reductions by 2020.[78] The only policy initiative that underwent a change in the reporting year is the natural gas demand side management program, discussed in more detail below.

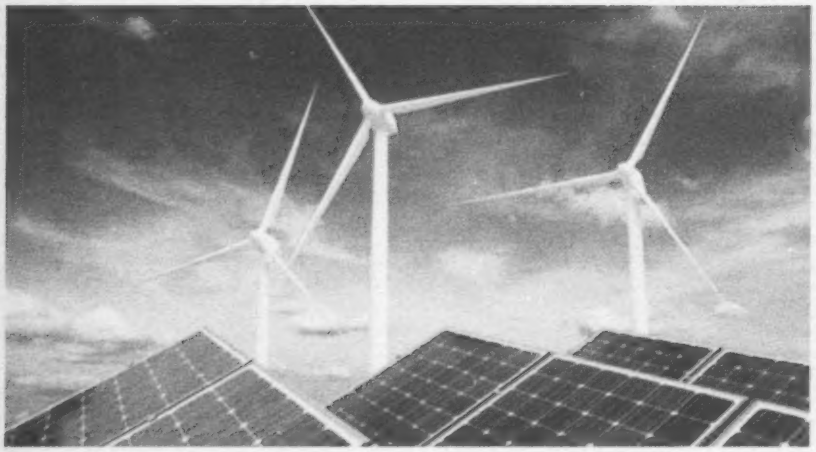
Natural Gas Demand Side Management Programs

The province's main initiative to reduce natural gas use in the buildings sector is through demand side management (DSM) programs, which are programs designed to reduce consumer demand for energy. These programs are offered by the natural gas utilities, with provincial oversight and guidelines.[79]

The Ontario Energy Board sets the DSM budgets for the natural gas utilities in multi-year plans.[*] The provincial framework for DSM programs was updated in 2014.[80] There are two main changes that are relevant to the sector's GHG emissions. First, the Minister of Energy issued a directive to the Ontario Energy Board in March 2014, ordering the Board to bring natural gas DSM into closer alignment with the Ontario government's Conservation First energy policy, which should increase the focus on natural gas conservation. Second, when the natural gas utilities conduct cost-benefit analyses for proposed DSM programs, 15 per cent can now be added to the total estimated monetized benefits to account for environmental benefits.[81] An Ontario Energy Board letter from February 2015 specifically identified carbon reduction as one of the environmental benefits to be considered.[82] As a result of these changes, more DSM programs may pass the cost-benefit test and be approved, which could further reduce emissions in the sector.

The Ontario Energy Board also significantly increased the recommended maximum annual budget for natural gas utility DSM spending to $135 million, more than double the $65 million approved for 2014.[83] It remains to be seen whether the gas utilities will spend their maximum budgets in order to pursue as much conservation as possible.

[*] These budgets are capped to discourage any potential upward pressure on gas rates.



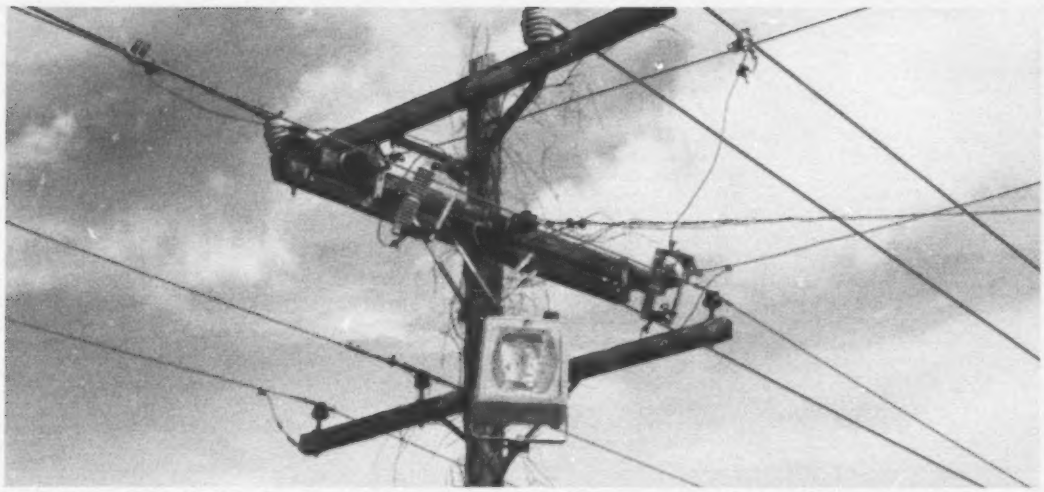
3.5 Electricity

The electricity sector's contribution to Ontario's GHG emissions continues to decline. In 2013, it represented 10.9 Mt or just 6 per cent of Ontario's total GHGs. Emissions from the sector peaked in 2000, but have fallen significantly since 2007 due to the closure or conversion of Ontario's coal-fired power plants.[84] The last coal-fired power plant, operated by Ontario Power Generation, stopped burning coal in April 2014. The bulk of the remaining GHG emissions from the power sector come from the 29 natural gas-fired power plants located across the province.[85]

Under the 2013 Long-Term Energy Plan, Ontario is expected to refurbish four nuclear units at Darlington generating station and six units at Bruce generating station between 2016 and 2031. Natural gas-fired power plants will fill some of the gap, which may increase the sector's emissions. The Independent Electricity System Operator[vi] projects an increase of about 1,040 MW in natural gas-fired generation capacity from 2016 to 2017 due to diminished nuclear supply.[86] After 2017, natural gas-fired supply is projected to stay constant. The rest of the supply gap is to be partially met by increases in low-carbon, non-hydro renewables (e.g., wind, solar) between 2017 and 2020 and through energy conservation after 2020. However, it is expected that additional energy resources will also be needed after 2020. These resources are classified as "Planned Flexibility," meaning that the government has not yet determined what type of energy source (or combination of sources) will be used.

Ontario is producing an ever-increasing share of its electricity from renewable energy sources such as wind and solar power.[87] As of Ferbruary 2015, there were 2,543 MW of installed wind capacity on the transmission grid – about 7.4 per cent of total system capacity.[88] By September 2016 a total of 280 MW of solar generation projects will be connected to the transmission grid.[89] This will complement approximately 2,500 MW of "embedded" solar and wind facilities – those connected to and located within the service areas of local distribution companies – that were in operation by May 2015.[90] By 2020, nearly 10,700 MW of non-hydro renewables will represent about 26 percent of total grid capacity.[91] Further, the government's Long-Term Energy Plan has indicated that renewable generation targets will be reviewed annually as part the Ontario Energy Report.

[vi] As a result of a government decision in 2014, the Ontario Power Authority and the Independent Electricity System Operator were merged into one agency, effective January 1, 2015, named the Independent Electricity System Operator, which will assume the functions of the two agencies.



Critics maintain that due to the intermittency of wind and solar power, there will always be a need for back-up generation, primarily provided by natural gas-fired plants (when the wind isn't blowing or the sun isn't shining). However, rapid developments in the field of energy storage are now challenging this assumption. In addition to advancements in battery technology being made outside of Ontario, there are many small demonstration projects in Ontario using a variety of technologies (e.g., compressed air, batteries and flywheels)[92,93] that will allow stored energy to be integrated into Ontario's grid. In 2014, the Minister of Energy directed the Independent Electricity System Operator to procure 50 MW of storage. So far, it has procured 33 MW with the remainder to be contracted in 2015. Additional government investment in smart grid technologies such as grid automation through its smart grid fund will also enable the integration of more renewable energy into the grid.

Many older natural-gas fired electricity generating stations currently operate under contracts that pay them for producing power around the clock, whether the energy is needed or not. These stations are known as non-utility generators (NUGs). Most NUG contracts will be up for renewal in the coming years. This presents a GHG emissions reduction opportunity, as under the new contracting framework, these plants should operate less frequently.[94] However, it is difficult to confirm that this will be the case, as NUG contracts renewed to date have not been made public. The province appears to be reviewing its approach to NUG contract renewal. In late 2014, the Minister of Energy instructed the Independent Electricity System Operator to assess the framework for NUG contracting in Ontario, temporarily freezing procurement.[95]

3.6 Agriculture

Ontario's agricultural sector's GHG emissions have been steady at between 9.9-11 Mt since 1990.[96] Emissions in this sector largely result from fertilizer and manure use (55 per cent), methane from livestock (29 per cent) and manure management (16 per cent).[97] In Ontario's *Climate Change Update 2014*, the MOECC stated that the agricultural and waste sectors will only contribute 1.8 Mt (or 4 per cent) of Ontario's emissions reductions by 2020.

Ontario's *Climate Change Update 2014* mentions few concrete policies that could reduce the sector's emissions other than on-farm biogas facilities (which will contribute a reduction of only 11 kilotonnes in 2020) and tillage practices.[98] However, there are encouraging signs that the Ontario Ministry of Agriculture, Food and Rural Affairs is attuned to the need to promote and support a more comprehensive approach to soil management as a means to reduce GHG emissions in the sector (among other benefits). The Ontario government's *Climate Change Update 2014* mentions that the sector plays a critical role in the carbon cycle.[99] Improving soil health (e.g., through minimizing tillage, encouraging cover crops and crop rotations, and regularly applying compost to fields) can reduce the need for fertilizer, thus minimizing nitrous oxide (N_2O) emissions, and enable soil to sequester more carbon.[100]

3.7 Waste

Emissions in the waste sector have been steadily increasing since 1990, but fell slightly in 2013.[101] Most (92 per cent) of Ontario's 9 Mt of GHG emissions from this sector arise from methane generated in landfill sites, primarily caused by the anaerobic decomposition of organic waste.[102] The effects of methane emissions can be reduced by capturing methane and either flaring or burning it to generate electricity. Preferably, methane emissions can be avoided by decreasing or eliminating organics in landfill sites.

In 2008, Ontario implemented regulations requiring large landfills to capture and destroy generated methane (O. Reg. 216/08 and O. Reg. 217/08). However, there have been no new waste policies introduced during the period covered by this report that are aimed at further reducing the sector's GHG emissions. As the ECO has noted in previous reports, reducing (or banning altogether) organics from landfill sites would result in significant emissions reductions in the waste sector.

4. ECO Comment

The science is clear and beyond dispute: human-caused climate change is already affecting Ontario. Profound changes in our economy and way of life are essential, and the provincial government has a clear leadership role to play in enabling and promoting these changes. The province must create a policy environment that will steadily reduce the carbon footprint of our economy and lifestyles. The costs of climate inaction are material, while the potential economic opportunities from transitioning to a low-carbon economy are substantial.

Ontario has made noteworthy strides in climate change policy since 2007, particularly by closing its coal-fired power plants and thus decarbonizing its electricity sector to a large degree. Unfortunately, this bold action was followed by a period of relative inaction. As a result, under the current suite of policy initiatives, Ontario will not meet its 2020 GHG emissions reduction target; nor will it ensure the province is prepared to manage climate change risks.

Encouragingly, the government has recently recognized the urgent need to act, and has signalled its intention to introduce policies that could put Ontario on a path to meeting its 2020 (and beyond) GHG targets. Over the past year, the government made several policy announcements for the transportation, building, electricity and industrial sectors that should result in GHG reductions over time. These are promising signs, but far more aggressive policies are still needed across all sectors to close the 2020 emissions gap. The government's level of ambition on climate change is encouraging, but the short time period between the likely introduction of new (or enhancement of existing) GHG reduction policies and the year 2020 make achieving the target extremely challenging.

In our 2014 Greenhouse Gas Annual Progress Report, the ECO recommended policy approaches with the potential to achieve substantial GHG emissions reductions in the transportation sector. These recommendations remain relevant and include: more transit-friendly urban planning; increased investments in public transit; and better efforts to encourage the use of low carbon fuels, and energy efficient and alternative energy vehicles.

In the buildings sector, the ECO believes that this year's developments at the Ontario Energy Board should result in a greater number of natural gas conservation programs, and will hopefully reduce the building sector's carbon footprint.

In the electricity sector, the ECO is encouraged by the longer-term move away from fossil-fuel based electricity sources and the potential for improved electricity storage technologies. The public interest would benefit from full transparency of all energy procurement contracts, particularly with regards to non-utility owned natural gas plants, whose production contracts are not tied to the province's actual energy needs.

For industrial emitters, the introduction of a cap-and-trade program would mark a huge change in the government's approach to reducing emissions in this sector. If designed well, there is the potential for significant emissions reductions.

In the agricultural sector, policies that support healthy soils (which sequester more carbon) should be considered. Phasing out organics from landfill sites would help reduce emissions in the waste sector.

Finally, to more transparently connect projected GHG emissions reductions to specific government initiatives, the ECO recommends that the MOECC provide estimated breakdowns of GHG emissions reduction projections for each initiative, and for each sector.

Beyond the fanfare of the United Nations Framework Convention on Climate Change conference in Paris in December 2015, the hard work of implementing more stringent GHG reduction policies will begin. With this in mind, the ECO looks forward to tracking the province's future progress in reducing its GHG emissions.

Appendix 1 – IPCC's New Science: A Call to Mitigate and Adapt

Last year's ECO Annual GHG Report highlighted the pivotal climate change science released by Working Group I of the Intergovernmental Panel on Climate Change (IPCC); specifically, the IPCC's finding – with 95 per cent confidence – that human activities have been the dominant cause of climate warming since the 1950s.

Since the ECO's last progress report, the IPCC's Working Groups II and III released their respective findings focused on climate change impacts, adaptation and vulnerability, and on mitigation. The IPCC also released a *Synthesis Report* (SYR) summarizing the work of all three working groups. Together, these reports identify a wide range of future climate change risks and call upon all levels of governments to:

1) take mitigating actions now, to ensure maximum efficiency, limit costs and minimize risks of abrupt and irreversible climate change impacts; and
2) take adapting actions *now*, to limit the negative effects of those climate change impacts, which are unavoidable even in the best-case emissions reduction scenarios, to minimize cost and maximize resiliency of people and ecosystems.

The IPCC's findings are particularly relevant to Ontario, as subnational governments play a key role in both adaptation and mitigation efforts.[104] Accordingly, this section will provide an overview of the IPCC's most recent findings regarding mitigation and adaption measures as set out in the *Synthesis Report*.

Impacts, Hazards and Risks Identified by the IPCC Report

The IPCC outlines various climate change **impacts** that have occurred on people and ecosystems. Each observed impact is provided with its associated certainty rating that expresses the likelihood or confidence level that it is related to climate change; these impacts include:

- a decrease in cold temperature extremes and an increase in warm temperature extremes, increased heat waves in some regions (*likely*), causing increased heat-related mortality (*medium confidence*);
- increased frequency and intensity of heavy precipitation events in North America and Europe (*medium confidence*);
- changing precipitation patterns and melting snow and ice, affecting the quantity and quality of water resources in some regions (*medium confidence*);
- shifted geographic ranges, abundances and interactions of many species (*high confidence*); and
- an overall decrease in crop yields (*high confidence*).[105]

Certainty for IPCC findings is based on the authors' evaluations of the underlying scientific evidence and agreement. Where appropriate, findings are expressed as facts. Otherwise, certainty is expressed either as a qualitative level of confidence (from very low to very high) or probabilistically with a quantified likelihood of something occurring (e.g., very likely represents 90–100 per cent likelihood, likely represents 66–100 per cent likelihood, more likely than not represents >50–100 per cent likelihood). In some cases the level of underlying scientific evidence (limited, medium, or robust) and agreement (limited, medium, or high) is indicated. (Source: IPCC, 2014: Climate Change 2014: *Synthesis Report of the Fifth Assessment Report*, p.1).

The IPCC uses the term **"hazard"** broadly to mean the potential occurrence of many effects, including: climate-related physical events or trends or their physical impacts that may cause loss of life, injury, or other health impacts, damage and loss to property, infrastructure, livelihoods, service provision, as well as degradation of ecosystems, and environmental resources.[106] As a result of the unavoidable increase in temperature throughout this century, the IPCC predicts the following climate-related hazards:

- Heat waves will occur more often and last longer (*very likely*);
- Fewer cold temperature extremes and more frequent hot temperature extremes will occur (*virtually certain*);
- Extreme precipitation events will become more intense and frequent in many regions (*very likely*);
- Arctic sea ice will continue to recede;
- The ocean will experience increased acidification;
- Glacier volume, with few exceptions, will decrease by at least 15 per cent (*medium confidence*); and
- The ocean will continue to warm and the mean sea level rise (*very likely*).[107]

Climate change **risks** result from the interaction of climate related hazards (events and trends) with the vulnerability and exposure of human and natural systems, including their ability to adapt.[108] The climate change hazards set out above are predicted to result in the following risks, among many others:

- Extinctions of a large fraction of species (*high confidence*);
- Threats to global food security in a business-as-usual emissions scenario, combined with increasing food demand (*high confidence*); and
- Major impacts on water supply, food security, infrastructure, and agricultural incomes for those in rural areas.

More generally, in urban areas, heat stress, storms, extreme precipitation, flooding, landslides, air pollution, and water scarcity will increase risks to people, assets, economies and ecosystems (*very high confidence*) – especially for people lacking essential infrastructure and services.[109]

The risk of irreversible and abrupt changes in the climate system increase as the magnitude of warming increases.[110] Without additional mitigation efforts – under the business-as-usual scenario – most models predict warming is more likely than not to exceed 4°Celsius (C) above pre-industrial levels by 2100.[111] The above-noted risks will be exacerbated in such a scenario.[112]

In response to these predicted climate change risks, the IPCC outlines a variety of complementary mitigation and adaptation opportunities aimed at avoiding the most significant negative impacts on humans, animals, and the built and natural environment.[113]

Mitigation Efforts Proposed by the IPCC

The IPCC uses several emissions[viii] scenarios to model future climate change risks based on differing degrees of mitigation. Even its most aggressive emissions mitigation scenario involves increased warming until 2100 relative to the present temperature due to concentrations of greenhouse gases (GHG) already in the atmosphere.[114] The amount of global warming for the latter half of this century will depend greatly on the extent to which emissions have been mitigated (i.e., aggressive versus business-as-usual) in the first half of this century.[115] (see **Figure 1**).

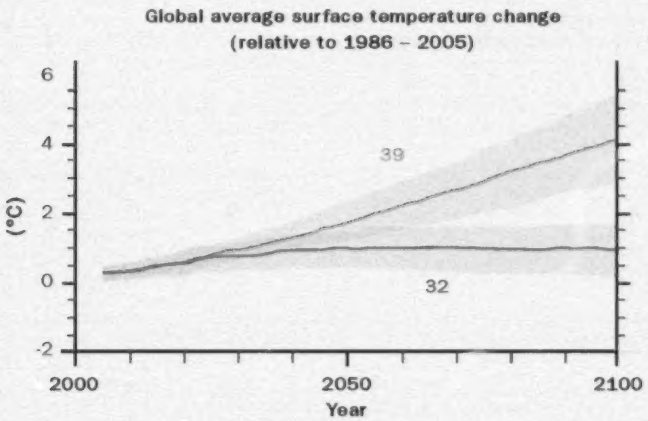


Figure 1: Global average surface temperature change from 2006 to 2100 as determined by multi-model simulations. All changes are relative to 1986–2005. A measure of uncertainty (shading) is shown for the best-case mitigating scenario (blue) and the worst-case (i.e., business-as-usual) (red). The number of models used to calculate the mean is indicated. (Source: IPCC, *Climate Change 2014: Synthesis Report of the Fifth Assessment Report*, 2014, Fig. 2.1(b))

The IPCC believes that the mitigation efforts listed in the box on the right, undertaken now and within the next few decades, can significantly reduce exposure to climate change risks within this century.

Limiting warming to a less than 2°C increase over pre-industrial levels (generally considered the tipping point for severe and irreversible climate change risks)[116] will require substantial emissions reductions over the next few decades and near-zero emissions of GHGs by the end of the century.[117] The sooner mitigation actions are taken, the better the odds for effective adaptation, and the lower the costs and challenges of mitigation in the longer term.[118] For example, delaying mitigation activities, even to 2030, would require substantially higher rates of emissions reductions, a more abrupt shift from high-carbon to low-carbon energy use, more reliance on carbon dioxide removal technologies, and a higher rate of spending.[119]

[viii] The IPCC's AR5 provides climate projections based on "scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases, aerosols, chemically active gases, as well as land use/land cover," the AR5 refers to these scenarios as representative concentration pathways (RCPs), namely: RCP 2.6, RCP 4.5, RCP 6, and RCP 8.5. These four scenarios range from business-as-usual (RCP 8.5), in which emissions continue increasing over time, to RCP 2.6 in which emissions are reduced substantially over time. (IPCC, report, *Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., et al. (eds.)] Glossary, p.1461, 2013.)

Examples of IPCC Suggested Mitigation Policies and Measures

(Certainty notations relate to the likelihood that the policy or measure would have a GHG mitigating effect)

Cross-sectoral

- Reducing subsidies for GHG-related activities (*high confidence*).
- Putting a price on carbon, either by use of strict caps that have a restraining effect or taxes that have restraining and substitution effects, if imposed alongside other complementary policies (*high confidence*).

Electricity Supply

- Decarbonizing electricity generation (*medium evidence, high agreement*), by way of:
  - o renewable energy subsidies (*high confidence*); and
  - o supporting technology development, diffusion and transfer (*high confidence*).

Energy Demand

- Efficiency enhancements and behavioural changes (*robust evidence, high agreement*), by way of energy efficiency regulations and labelling (*medium evidence, medium agreement*).

Forestry

- Afforestation, sustainable forest management and reduced deforestation (*medium evidence, high agreement*).

Agriculture

- Cropland and grazing land management, and restoration of organic soil (*medium evidence, high agreemet*).

The IPCC observed that mitigation policies are more cost-effective if they integrate multiple approaches across various sectors, such as: reducing energy demand and the GHG intensity of key sectors like transport, industry, and buildings; decarbonizing the energy supply; and increasing carbon sequestration opportunities.[121]

Adaptation Strategies Proposed by the IPCC

The IPCC report states with high confidence that adaptation measures can help secure populations, assets, and ecosystem goods against the climate change risks outlined above; however, the IPCC notes that there are limits to their effectiveness, particularly in the face of unmitigated climate change.[122] The IPCC recommends a range of adaptation measures; see box.

Examples of IPCC Suggested Adaptation Policies and Measures [123]

- Hazard and vulnerability mapping (e.g., flood plain mapping).
- Storm and wastewater disaster risk management and structural and physical improvements.
- Transport and road infrastructure improvements.
- Ecosystem management (e.g., maintaining wetlands, watershed, and urban green spaces).
- Power plant and electricity grid adjustments.
- Ecological restoration (e.g., soil conservation, reforestation, and afforestation).
- Green infrastructure development (e.g., shade trees, green roofs).
- Sustainable fisheries management (e.g., control overfishing and fisheries co-management).
- Assisted species migration and dispersal (e.g., ecological corridors).
- Financial incentives (e.g., payment for ecosystem services).
- Disaster planning and preparedness.
- Education (including sharing indigenous, traditional, and local knowledge, and knowledge sharing and learning platforms).

Adaptation policies need to address current vulnerability and exposure to climate change risks, while also incorporating a longer-term perspective.[124] The IPCC outlines several methods for improving adaptation planning and implementation, including the need for research and monitoring of adaptation effectiveness, co-ordinated and complementary actions across all levels of government, and public education about climate change risks.[125]

Appendix 2 – Climate Trends and Projections for Ontario

Climate data and projections drive climate change mitigation and adaptation policy. Climate science is continuously evolving and there is a large body of scientific research on the subject (even in Ontario), making it difficult for Ontarians to critically assess all the available science. At the international scale, the IPCC plays a critical role in providing authoritative climate science (although it does not endorse any specific projections), including some regional climate information. There is no comparable authoritative scientific body that vets and synthesizes Ontario-specific climate science. It is not the ECO's role to assess and aggregate all climate science applicable to Ontario. However, given the importance of using available climate science to make decisions, this section presents an illustrative range of climate projections that have been made for Ontario, as well as past observations that showcase how Ontario's climate is changing.

In the absence of an IPCC-like body for Ontario, the ECO reviewed federal and provincial climate change reports that have taken on the task of critically analyzing and synthesizing the best available information.[a] Much of the government's regional-specific climate data and analysis, however, is already several years old (in many cases from 2008 or earlier), pointing to a clear need for more current Ontario-specific data. In addition, in assessing the various projections, it is important to understand the nuances of climate modelling that can lead to widely ranging projections. Different researchers use different base climate models, incorporate different parameters (or integrate them into the model in different ways), use different techniques to downscale the data to a more local level (or don't downscale at all), and so on.

It is important to note that climate projections vary based on the climate model and emissions scenario used. For further information about the climate projections summarized in this Appendix, please see the original sources listed in the endnotes.

Over the past few decades, Ontario's climate has exhibited a marked increase in temperature that has outpaced the global average. While the global average temperature has increased by 0.85 degrees Celsius (°C) since 1880[126], according to recent research out of York University, Ontario's summer and winter temperatures rose by an average of 1.0°C and 2.2°C, respectively, between 1900 and 2012.[127] Correspondingly, the number of frost days per year in Ontario decreased by 18 days between 1979 and 2009.[128] Natural Resources Canada (NRCAN) research from 2008 found that northern Ontario generally has experienced a higher rate of warming than southern Ontario; findings that were supported by recent downscaled climate projections under the IPCC's AR5 scenarios (see **Appendix 1**) by York University's Laboratory of Mathematical Parallel Systems (LAMPS) in 2014.[129, 130]

Ontario's annual average temperatures are expected to continue climbing. In fact, warming in Ontario is predicted to continue along the historic trend to outpace global increases; for example, the IPCC estimates that warming near the Great Lakes is projected to be about 50 per cent

[a] Appendix 2 summarizes the scientific findings featured in reputable reports, such as the most recent reports from the IPCC, Ontario's (then) Ministry of Natural Resources (MNR), Natural Resources Canada (NRCAN) and the National Round Table on the Environment and the Economy (NRTEE). It is important to note that much of this government-endorsed or mandated regional-specific climate research needs to be updated. More recently, the MOECC funded (but does not endorse) Ontario-specific climate change science via grants to several academic institutions, including the University of Toronto. The ministry also funded interactive public climate data portals produced by the University of Regina (Ontario Climate Change Data Portal) with climate data and projections provided at a resolution of 25 km², and a at a resolution of 45 km² by York University's LAMPS laboratory, each based on different climate models.

greater than that of the global mean warming. Moreover, northern Ontario is forecast to continue warming faster than southern Ontario, especially with regard to winter temperatures (See **Table 1**). The trends are consistent across most climate research. For example, ongoing research from the University of Toronto (partially funded by the MOECC) that focuses on capturing the impact of the Great Lakes on Ontario's climate found that Southern Ontario would experience 2-3°C of average annual warming in 2050-2060 compared to 1979-2001, whereas northern Ontario would experience 3-4°C.[132]

Table 1: Summary of MNR, NRCAN and NRTEE Climate Projections for Ontario.[133]

	Southern Ontario	Northern Ontario
Changes in Temperature		
Summer	• Southern Ontario is expected to increase by 2-4°C by 2050, and by 4-5°C by 2071 • Southwestern Ontario is expected to increase by 5-6°C by 2071.	• Northern Ontario is expected to increase by 2-4°C by 2071.
Winter	• Southern Ontario is expected to increase by 2-5°C by 2050.	• Northern Ontario is expected to increase by 2-7°C by 2050. • The Hudson Bay area is expected to increase by 9-10°C by 2071. • The northwestern section of Ontario's Far North is expected to increase by 8-9°C by 2100.
Changes in Precipitation and Flooding		
	• Southern and central Ontario are expected to receive anywhere from 10 per cent more to 10 per cent less summer precipitation by 2050, depending on the region. • Southern Ontario flooding is expected to increase by 10-35 per cent by 2046-2065, and by 35-50 per cent by 2081-2100.	• Overall, northern Ontario is expected to receive 10-20 per cent more precipitation between spring and fall, and 10-40 per cent more winter precipitation. • But, parts of northwestern Ontario are expected to receive anywhere from 10 per cent less to 20 per cent more summer and winter precipitation.[134]
Changes in Freezing Rain Events		
	• Total number of freezing rain days between December and February are expected to increase by 35-100 per cent by 2046-2065, and by 35-155 per cent by 2081-2100. This trend will be exacerbated farther north.	
	• Toronto and Windsor are expected to experience 35-55 per cent more freezing rain days by 2045-2065.	• Kenora, Thunder Bay and Timmins are expected to experience 70-100 per cent more freezing rain days by 2045-2065.
Changes in Water Surface Temperature		
	• Great Lakes surface temperatures are expected to continue the current warming trend, increasing by an additional 2.5-4.4°C by 2100.	

Along with rising air temperatures, water temperatures are warming as well. The National Round Table on the Environment and the Economy (NRTEE) reported in 2010 that between 1968 and 2002, Lake Huron warmed by 2.9°C, Lake Ontario warmed by 1.6°C, Lake Erie warmed by 0.9°C and since 1980, Lake Superior warmed by 2.5°C.[135] Great Lakes surface temperatures are expected to increase by an additional 2.5-4.4°C by the end of the century, according to a 2008 MNR report.[136] Similar warming trends were observed by a MNR study in 2007 for the lakes further north.[137]

Rising temperatures also affect the amount and timing of precipitation. Changes in rain and snowfall patterns are already evident in much of Ontario. For example, between 1990 and 2008 annual precipitation had already increased between 5-35 per cent in some parts of southern Canada.[138] However, precipitation patterns are regionally variable; recent data out of York University indicates that there has been a greater increase in both summer and winter precipitation with spatial variations from region to region; southern and central Ontario has experienced more increased winter precipitation than northern Ontario, while summer rainfall has increased more in northwestern and central Ontario than in other regions.[139]

Although total annual precipitation is projected to increase for the province overall, regional and seasonal variations are predicted to continue. For example, a 2008 Ministry of Natural Resources (MNR) study and a 2007 NRCAN study conclude that parts of southwestern Ontario could experience reduced summer and fall precipitation,[140] and the same MNR study suggests that certain areas of northwestern Ontario may also receive less summer and winter precipitation (see **Table 1**).[141]

Increases in precipitation do not necessarily occur smoothly – a changing climate is also a volatile one. The 2008 MNR study referenced above also states that precipitation will often come in the form of more frequent and intense storms,[142] something that the province has already begun to experience (see Chapter 4 of the ECO's 2014 GHG Annual Report). This trend will only strengthen; in 2014 an NRCAN study concluded that flooding due to storms is expected to increase in southern Ontario anywhere from 10-50 per cent by the end of the century (see **Table 1**).[143] This same study projected that extreme weather will extend into the winter season as well; more freezing rain days are expected province wide, with parts of northern Ontario experiencing the greatest increase (see **Table 1**).[144]

A warming climate will also affect ice cover and permafrost (ground that is frozen at or below 0°C for at least two consecutive years). According to a 2012 MNR study, warmer air and water temperatures mean that Ontario's lakes will be covered in ice for shorter periods and that ice thickness will decrease.[145] A 2014 NRCAN study projected that the warming climate is expected to melt and degrade permafrost across Canada, including in Ontario's Far North.[146] In turn, warming of Ontario's Far North, an ecosystem with some of the highest soil carbon densities in the world, is predicted to substantially alter the area's carbon storage capacity.[147]

Ontario's Ecosystems in a Changing Climate

Ontario's biodiversity is under enormous pressure from a variety of threats, including pollution, fragmentation and loss of habitat, invasive species and unsustainable harvesting of species. Climate change presents another major threat to species and ecosystems, both in and of itself, and in its potential to compound or catalyze other existing pressures.

Rising air and water temperatures, along with changes to rain and snow patterns, will reshape the ecology of the province. Some native plants and animals will be able to move with or adapt to these changing conditions, others will not. The ranges of other species – not previously found in Ontario – will expand into our province.

The effects of climate change – including increasing air and water temperatures, decreasing ice cover, and changes in precipitation – will alter Ontario's aquatic ecosystems. The then MNR noted that the effects of climate change will affect fish distribution, growth, reproduction, and survival. Rising water temperatures may cause a substantial decline in the productivity of some cold-water species (such as lake trout and brook trout), while many warm-water fish are projected to benefit from rising temperatures. For example, the habitats of smallmouth bass and walleye are expected to expand in northern Ontario;[148] this northward expansion of some fish species, however, can in turn disrupt other existing cold-water fish populations.[149]

These changes to Ontario's ecology will have profound repercussions. Indeed, Ontario's Biodiversity Council warned that climate change has the potential to dramatically alter our province's natural environment. According to this council, the potential effects of climate change on biodiversity include:[150]

- Changes in species' distributions (e.g., scientists have already observed northward shifts in some species' ranges);
- Changes in the timing of events, like the flowering of plants and the breeding and migration of animals; and
- Changes in the interactions between species that interrelate and/or depend on each other for survival (i.e., predators and prey; insects and host plants; parasites and host insects; and insect pollinators and flowering plants), for example, the timing of important events in the species' respective life cycles can become out-of-sync.

Ontario's Biodiversity Council's *2010 State of Ontario's Biodiversity* report contains specific indicators related to climate change that show worsening trends, including those related to ice coverage of all the Great Lakes in recent decades as well as reduced survival rates for the province's polar bears.[151]

The Ontario government's Far North Science Advisory Panel echoed many of these concerns about the current and future impacts of climate change for northern Ontario.[152] From the loss of peatlands, to melting of permafrost, to species' shifts in the boreal forest, the ecological effects of warming temperatures will cause sweeping environmental changes.

In southern Ontario, scientific experts appointed by the government have also warned about the ecological impacts of climate change. For example, the Lake Simcoe Science Committee identified that climate change has already had measurable effects on that watershed for which action is required now. These experts outlined the scope of impacts including on water quality, water quantity, water use, species composition, terrestrial habitat quality, the occurrence and abundance of native and invasive species, fish spawning times and production, fishing opportunities, stream flow, and plant and animal diseases.[153] The binational International Joint Commission has reported similar concerns affecting all parts of the Great Lakes[154] and the Ontario's government's Expert Panel on Climate Change Adaptation also raised profound concerns about these types of ecological impacts.[155]

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[111] Ibid, Figure 2.8(b).

[112] Ibid, s.3.2.

[113] Ibid, s.3.

[114] Ibid, s.2.2.

[115] Ibid, s.2.2.1.

[116] For example, see: UNFCC, *Copenhagen Accord*, 2009, Article 1:

> 1. [...] To achieve the ultimate objective of the Convention to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, we shall, recognizing the scientific view that the increase in global temperature should be below 2 degrees Celsius[...]

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[118] Ibid, s.3.4: "The challenges of implementing these necessary mitigation policies (technological, economic, social, and institutional) only increase with delays."

[119] Ibid, 3.4.
[120] Ibid, s.4.3.
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